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SYSTEM FOR METEOROLOGICAL SATELLITES IN CHINA

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DEVELOPMENT OF DATA RECEIVING AND PROCESSING
SYSTEM FOR METEOROLOGICAL SATELLITES IN CHINA

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ABSTRACT: Meteorological satellites have high application
effectiveness. To receive data from the polar meteorological
satellite (Fenyun 1) and the geostationary satellite (Fenyun 2)
of China, as well as from NOAA and GMS satellites, Fenyun 1 and
Fenyun 2 meteorological satellite data receiving and processing
systems were established at the National Satellite Meteorological
Center of the China Meteorological Administration. The article
briefly discusses and comments on the developmental process,
present status, and future development trends of these two major
systems, as well as other ground application systems of
meteorological satellites in China.

I. Foreword

A meteorological satellite is one of the major application-
satellite series in the present world. Such satellites not only

have important functions in weather forecasting, especially in monitoring and forecasting of catastrophic weather, in addition to monitoring weather, natural calamities, the environment, aviation, and oceanic navigation, and very great economic benefits can be generated for society.

To adequately exploit the functions of meteorological satellites, not only should advanced meteorological satellites be available, but also advanced and well-functioning ground data receiving and processing systems. Like satellites, a ground system is a complex system integrating numerous disciplines and high technology, including electronics, communications, computers, remote sensing, meteorology, and various branches of geographic science.

With the commercial span of meteorological satellites on a global scale, as well the development of computer technology, in the late seventies large-scale data receiving and processing systems for meteorological satellite were built successively in the United States, Japan, and European countries. From the eighties to the present time, these systems are continuously undergoing improvements with new generations. India, Australia, and other countries also built up smaller systems.

Receiving and applying meteorological satellite data from abroad began in the seventies in China; however, the buildup of modern ground systems has been mainly in the decade just past. The development has been very rapid. In the following, brief description and comments are made on the developmental process of

meteorological satellite ground stations in China, large-scale
data receiving and processing systems at the National Satellite
Meteorological Center, microcomputer data processing systems of
local stations, and developmental trends of these systems in the
future.

II. Developmental Process of Data Receiving and Processing
Systems on Meteorological Satellites in China

Beginning in the early seventies, China began to
successively receive and apply data from polar orbit and
geostationary orbit meteorological satellites of the United
States and Japan, develop and fabricate antenna and receiving
systems, generate black-and-white cloud photographs of HRPT, APT,
and GMS with fax machines, weather forecast service from the
cloud-map analysis, as well as monitoring, warning, and
forecasting of such catastrophic weather systems as typhoons and
rainstorms. These functions are significant.

In the early eighties, the Center imported a set of TIROS-N
series satellite data single-station receiving and processing
system. There are two components of the system: one is the data
receiving and processing system, with HP-1000 minicomputers and
M-70 graphic processors; and the other is the quantitative data
processing system with an IBM-4380 computer. Data exchange
between the two subsystems is through CCT magnetic tape. This
system was aided by the United Nations Development Organization.
Among similar systems of United Nations aid to the third world,
the working conditions of this system are among the better ones.

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Many developmental tasks were performed, thus winning praise from the World Meteorological Organization. This system is used not only in weather forecasting, but also in environmental monitoring, such as the forest fires in the Greater Xing'an Mountains in 1987. At about the same time, in 1983 a set of MCIDAS system was imported from the University of Wisconsin in the United States by the Institute of Atmospheric Physics, Chinese Academy of Sciences. The MCIDAS system is used with an IBM-4331 computer for satellite meteorological research. These two systems give references to build China's meteorological satellite ground system.

These are milestones for the completion of the ground data and receiving system of the Fenyun 1 (FY-1) by the end of 1987, and the launch of FY-1 as China's first polar-orbit meteorological satellite made on September 7, 1988. These milestones indicate a new stage of meteorological satellites and satellite meteorological undertakings in China. The ground station of the FY-1 was designed and built in China with a 24-h round-the-clock large-scale operating system, with functions and technical levels quite close to the data receiving and processing system of the National Environmental Satellite and Data Information Service Administration (NESDIS) of the United States.

This system has been operating normally for seven years, not only successfully receiving and processing data from China's two FY-1 satellites, but also receiving and processing data from NOAA and GMS satellites for data filing as well as extensive data

distribution and services in the entire application fields, thus acquiring application effectiveness in multiple aspects.

After completion of the FY-1 ground system, to receive and process data from the FY-2 geostationary meteorological satellite that will be launched in China, immediately afterwards construction of the ground application system of the FY-2 began. At present, this system has been fundamentally completed; the system is composed of command and data receiving stations, a satellite operational control center, a data-processing center, distance measuring stations, intermediate and small-scale application stations, S-wave segment weather chart receiving stations, and a communication system with functions and technical levels quite close to the GMS ground system of the Japan Meteorological Department. This is also a large-scale professional system.

In the construction of these systems, a contingent of satellite meteorological scientific and technical personnel has been preliminarily formed, exerting strenuous efforts in system design, construction, data processing methods, and evolutionary theory studies, software development, and data analysis and applications. Although these undertakings still lag in some instances quite far behind the advanced international levels, a foundation has been laid on future development of satellite meteorological technology in China.

The volume of information embodied in the data of meteorological satellites is quite great, approximately three

orders of magnitude over conventional weather data. Although because of limitations in the communication conditions in China, after completion of the FY-1 ground system, the problem was not very well solved with regard to transmitting graphics and quantitative output of some large volumes of information to users throughout China by the Satellite Meteorological Center. With the rapid development of microcomputer technology in recent years, after 386 microcomputers came on the scene, multiple graphic processing can be conducted on meteorological satellite data, along with a certain capability of quantitative data processing. Therefore, given the microcomputer processing of meteorological satellite data at present, microcomputer systems are available at many provincial meteorological stations and many other departments with the capability of data receiving and processing from GMS or NOAA satellites. Such microcomputer systems play a major role in promotions and applications of meteorological satellite data.

III. Meteorological Satellite Data of the Receiving and Processing System of National Satellite Meteorological Center

The meteorological receiving and processing system of the Center is subdivided into two subsystems: FY-1 and FY-2. The former subsystem receives and processes polar-orbit meteorological satellite data. The latter subsystem receives and processes geostationary meteorological satellite data. Data filing and distribution services of the two subsystems are integrated.

(1) General conditions of FY-1 ground system

Classified according to services, the FY-1 subsystem is further classified into sub-subsystems of data receiving, communication transmission, computers, data processing, data filing, unified timing service, and command-dispatch, consisting of three stations, Beijing, Guangzhou, and Urumqi, and a data processing center at the National Satellite Meteorological Center at Beijing. Besides the capability of receiving and processing data from China's FY-1, this subsystem can also receive and process data from two NOAA satellites. Before completion of the FY-2 subsystem, the FY-1 subsystem has also been used to receive and process wider-ranging information of the GMS. Fig. 1 is a schematic diagram of the FY-1 subsystem.

Data received by the Guangzhou and Urumqi ground stations are sent in real-time to the data processing center via a high-speed data channel of the communication satellite, and via the domestic microwave communication channel. The data received by the Beijing ground station is transmitted in real time to the data processing center via a self-built microwave system. Between the center and the three stations, there are 2400bps data channels and telephone channels for mutual transmission, command, and dispatch of orbital data, remote sensing data, operating time schedules and equipment status. Between the center, on the one hand, and other departments such as the Xi'an Satellite Control Center and the National Meteorological Center, on the other, effective linkage and data transmission circuits have also been

established.
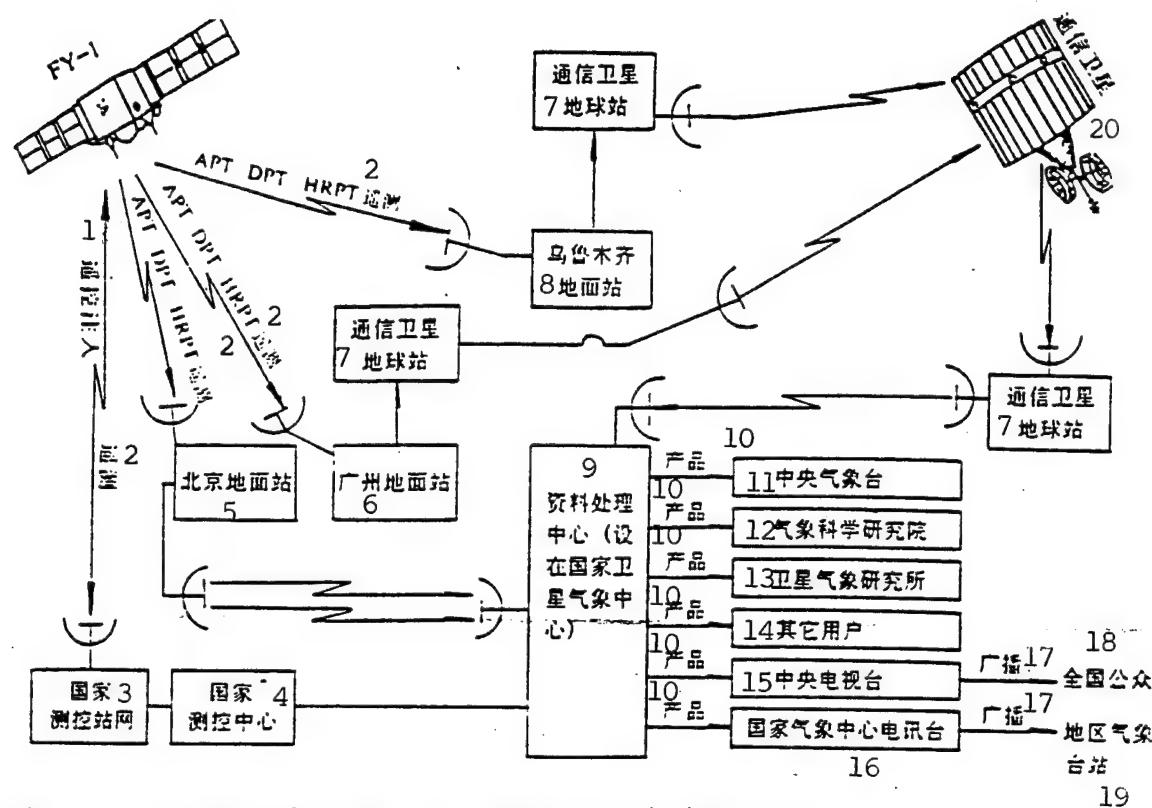
Fig. 1. Block diagram of data receiving and
processing system of Fenyun-1
KEY: 1 - insertion with remote control 2 - telemetry
3 - national network of telemetry and control stations
4 - national telemetry and control center 5 - Beijing ground
station 6 - Guangzhou ground station 7 - communication
satellite earth station 8 - Urumqi ground station 9 - data
processing center (in the National Satellite Meteorological
Center) 10 - product 11 - Central Meteorological Station
12 - Research Academy of Meteorological Science 13 - Institute
of Satellite Meterology 14 - other users 15 - Central
Television Station 16 - telecommunication station at the
National Meteorological Center 17 - broadcasting 18 - public
throughout the nation 19 - regional meteorological stations
20 - communication satellite

The data processing center collects the polar orbit

meteorological satellite data received at three ground stations,

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in addition to orbital parameters of the FY-1 satellite transmitted from the Xi'an Satellite Control Center, and TBUS orbital information and conventional meteorological data transmitted from the National Meteorological Center to be processed. In the computer systems at the center, the various execution programs operate on a time schedule by using the operational dispatch software in the processing system to generate graphics, picture outputs, and quantitative outputs as scheduled by time, for further generation of analytical outputs and special services. These outputs are provided to domestic users through screen display, fax machines, digital printout, television broadcasts, meteorological circuits, and other channels (meteorological, meteorological-communication). FY-1 satellite orbital information is sent to international users through GTS circuits. The original satellite data and important outputs are filed on magnetic tapes, video tapes, pictures, and printout.

(2) General situation of FY-2 ground system

Fig. 2 shows a block diagram of the FY-2 ground system.

The command and data acceptance station (CDAS) for the FY-2 is at the Beijing Station. There is an 18-m diameter antenna for receiving the original cloud map information transmitted from the FY-2 satellite with a code rate of 14mbps. After passing a synchronized data buffer (S/DB), digital expanded information is formed in real time. By using the time that the satellite remote sensing instrument is scanning into space, retransmission is made

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at the code rate of 660kbps.
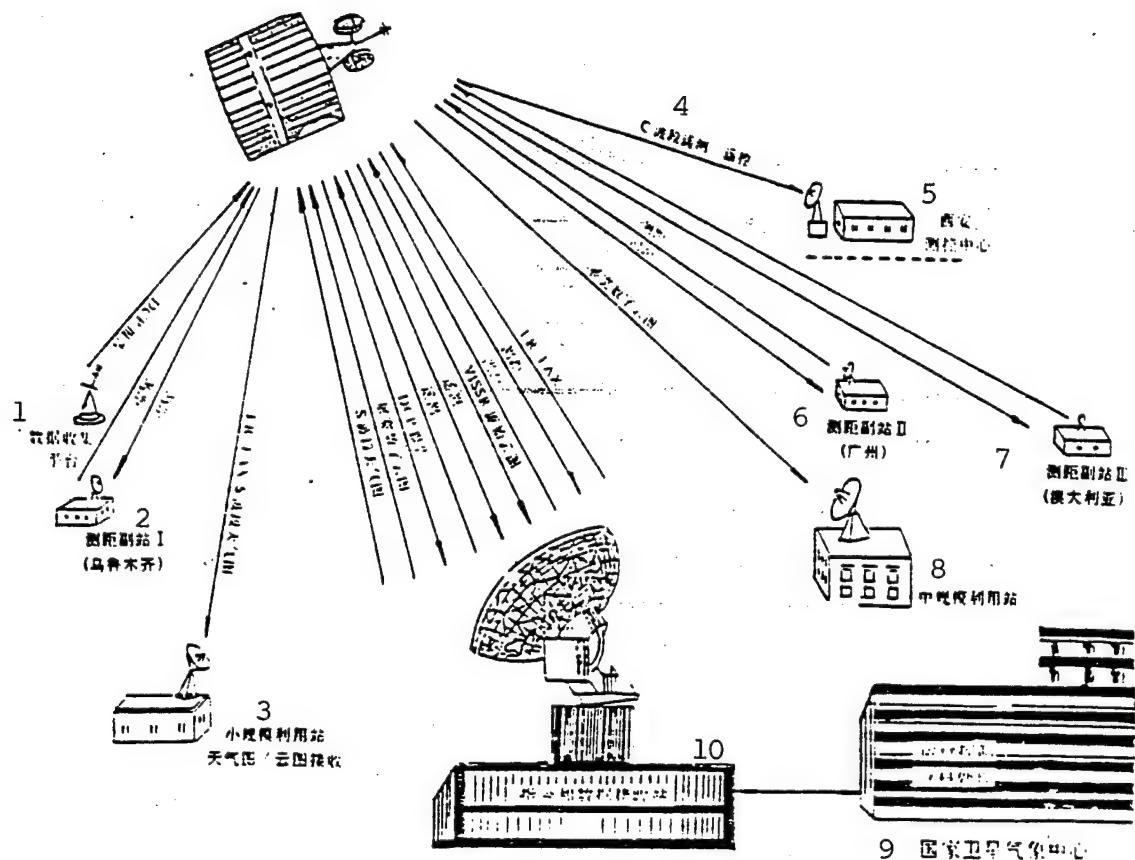
Fig. 2. Block diagram of application systems in FY-2
meteorological satellite
KEY: 1 - data collection   2 - distance measurement substation
(Urumqi)   3- small-scale utilization station for receiving
weather maps and cloud maps   4 - C-band telemetry and remote
control   5 - Xi'an control station   6 - distance measuring
substation II (Guangzhou)   7 - distance measurement substation
(Australia)   8 - medium-scale utilization station   9 - National
Satellite Meteorological Center   10 - command and control
receiving station

To determine the precise orbit of the satellite, a three-

point distance measuring system was set up. The main station for

distance measuring is within CDAS station at Beijing. Two

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substations for distance measurement were set up at Guangzhou and Urumqi. With cooperation from Australia, a substation for distance measurement was also set up at Melbourne. The other main tasks of the CDAS station include receiving telemetry signals (including data for space environment monitoring) from the FY-2 satellite, transmitting command signals of remote control at the satellite, and transmitting signals for weather maps and satellite cloud maps.

The system's operational control center (SOCC) and the data processing center (DPC) are in a building at the center of the National Satellite Meteorological Center. High and low-speed communication with the CDAS station is via fiber optic cables. The main task of the SOCC include control of the FY-2 operations. Based on the operational applications of the FY-2, daily satellite operational schedules are compiled to transmit remote control orders (including data collection platform) to the FY-2. In addition, the SOCC also monitors and controls the operations of the ground system. The DPC executes data processing, mainly including: (1) calculation of orbit and attitude, navigation with respect to landmarks, as well as preprocessing of positioning and determination of graphic data to generate S/DB operational parameters for transmission to the CDAS station to form expanded digitized cloud maps for S/DB. (2) Graphic processing is conducted to generate graphic outputs with low-resolution fax (LR/FAX) for transmission to the CDAS and the FY-2, for relaying to users. (3) Quantitative processing is conducted on visible

light, infrared, and water-vapor channel data to generate
meteorological parametric outputs, such as wind vector, cloud
parameters, and sea surface temperature. (4) Process and
distribute data collected from the data-collection platform
(DCP).

In both data processing stations of the FY-1 and FY-2
systems, medium and mainframe computers are deployed. Fig. 3
shows the layout. With respect to the FY-1 system, four IBM S/1
minicomputers are used as pre-processors to input satellite and
conventional meteorological data, as well as the transmission of
fax output. There are three sets of mainframe IBM 381-PO3
computers with disk capacity of approximately 25GB, to be shared
by three mainframes. Additionally, two sets each of 7350 and
5080 graphic and picture processors are installed to connect to
the NMC via a model 3725 communication controller for data
distribution. With respect to the FY-2 system, the input of the
expanded signal of the FY-2 and the GMS satellites is fed through
two sets of SNU-4/490 workstations. The mainframe computers are
two sets of Fujiton M77-10, with disk capacity of approximately
60GB. In addition, there are two sets of SUN4/490 graphic and
picture workstations, for connection to workstations via Ethernet
and multiple microcomputers for product distribution and service.
Between two mainframe systems, data exchange is conducted with a
shared hard disk. The satellite original data (after
preprocessing) and outputs are generally in the hard disks of two
systems for about 24h. The data filing is mainly on type 3480

magnetic tape.
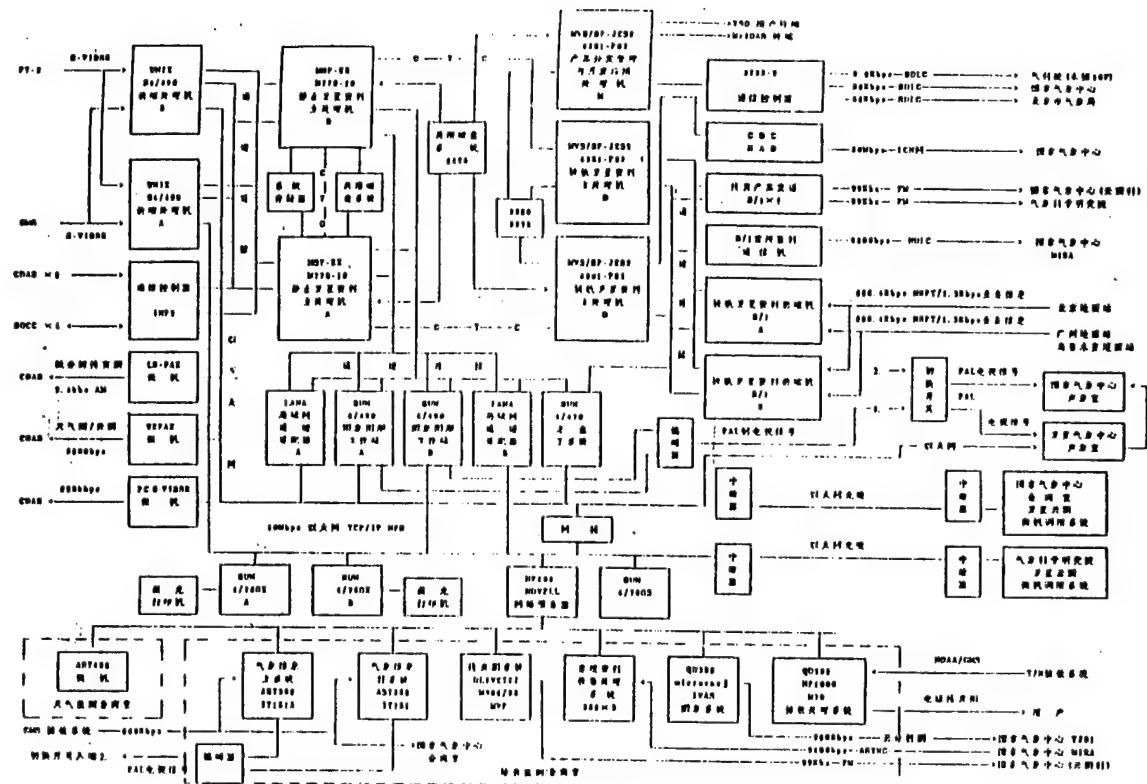
Fig. 3. Block diagram of computer systems at
the data processing center
KEY: [all items are illegible]

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Data processing is conducted in the FY-1 and FY-2 systems on applications. There are various contents, roughly subdivided into two categories of graphic processing and meteorological parameter processing. In graphic processing, polar orbit satellite data can be processed into single-orbit cloud maps, single-orbit expanded cloud maps, polar and equatorial projections, Mercator, and local maps. With respect to geostationary satellites, data can be processed into whole-view circular disk maps, regional maps, Mercator projection maps of low-latitude areas, as well as Lambert projection maps of mid-latitude areas for cloud analysis maps. With respect to various graphics, generally graphic processing of sliding, enhancement, amplification, multispectral integration, and false-color displays can be done. In meteorological parametric processing (quantitative processing), the outputs are cloud parameters, wind vectors, sea surface temperature, vegetation indicators, emitted long-wave radiation, atmospheric temperature and humidity contour lines, and total ozone levels. By using data from meteorological satellites, services can be rendered in dynamic monitoring of natural calamities and the ecological environment, such as forest fires, floods, droughts, blizzards, sandstorms, sea ice, estuarine silting, grasslands, crop growth, urban heat islands, and estimation of wheat harvests.

IV. Microcomputer Receiving and Processing System for Meteorological Satellite Data

The system is generally classified into polar-orbit

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meteorological satellite systems (for NOAA and FY-1 satellites),
and geostationary orbit meteorological satellite systems (for the
GMS and FY-2 satellites), with antenna sharing for time-division
operations. Fig. 4 is a block diagram of the microcomputer
system. Its fundamental accessories include antennas, receivers,
bit-frame synchronizers, buffers, and 386/486 microcomputers
(generally, it is required that the internal memory is greater
than or equal to 2 megabytes and the hard disk memory is greater
than or equal to 200 megabytes). With respect to graphic
processing of data from polar-orbit satellites, three-channel
integration diagrams are often required. Therefore, graphic
cards and large-screen displays should be attached. In addition,
printers, tape drives, optical disks, and video recording
interface can be attached, based on user requirements. In
addition, networking with other computers can be performed.

The microcomputer systems have limited capacity, and
frequently special systems are set up by users based on certain
purposes. The geostationary meteorological satellite
microcomputer system is used mainly for weather forecasting. The
polar-orbit satellite system is used mainly to monitor certain
natural calamities and ecological environments. The principal
software includes data input, preprocessing, graphic processing,
and data processing for certain applications. Generally
speaking, microcomputer systems are similar to the FY-1 and FY-2
systems, as their microcomputerization and simplification.

1
NOAA或GMS卫星

天线
2

双功能
3接收机

4
HRPT同步器

4
GMS 同步器

5
电子
开关

6 微机
转报
系统

7
常规气象资料

8 AT总线
缓冲器接口

RS232C

录像机或磁
带机接口
9

486
或
386
(≥IBM
内存)
10

11 图像
处理板

传真机
接口
12

彩色图
13
像监视器

14
编码器

15全电视
信号

传真机
16

录像机或
磁带机
17

18
软盘机

19
磁盘机

17
打印机
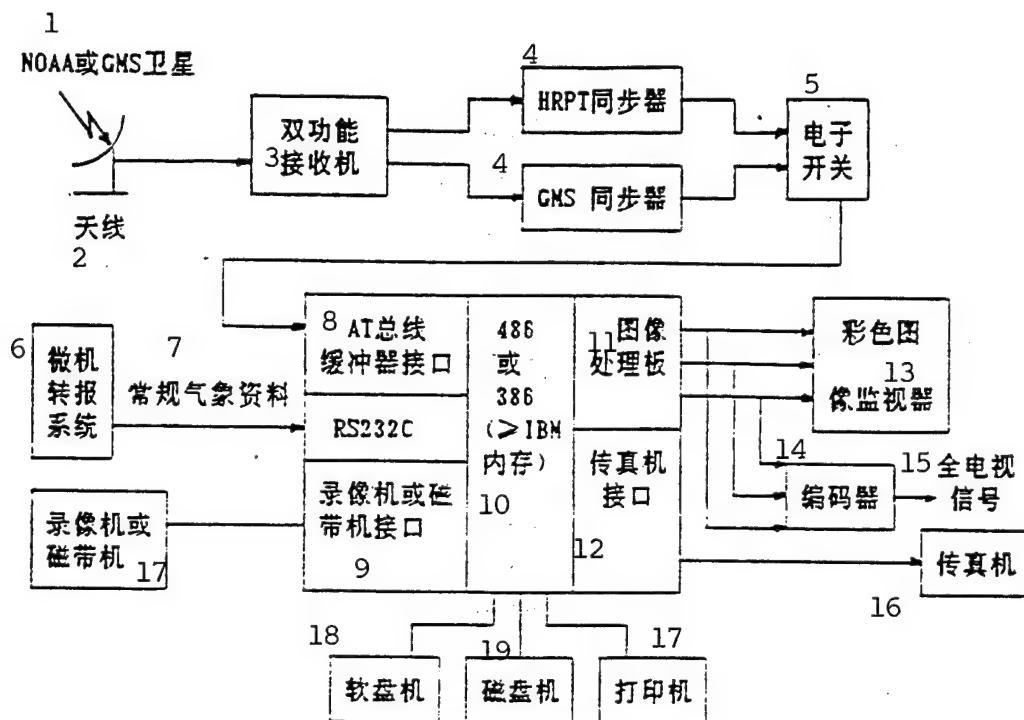
Fig. 4. Block diagram of data receiving and microcomputer processing systems in the polar-orbit and geostationary meteorological satellites.
KEY: 1 -NOAA or GMS satellites 2 - antenna 3 - dual-function receiver 4 - synchronizer 5 - electronic switch 6 - microcomputer relay system 7 - conventional meteorological data 8 - buffer interface in AT trunk line 9 - interface of video tape recorder or magnetic tape recorder 10 - 486 or 386 (greater than or equal to internal memory for IBM computer) 11 - graphic processing board 12 - fax machine interface 13 - color monitor 14 - code compiler 15 - all television signals 16 - fax machine 17 - printer 18 - floppy disk 19 - hard disk

V. Developmental Trends of Data Receiving and Processing Systems of Meteorological Satellites in China

The development of such data processing and receiving

systems is closely related to technologies of meteorological

satellites, communication, and computers, as well as exploration

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into applications of meteorological satellite data.

In the mid and late nineties, and the early 21st century, a new stage will be entered by domestic and foreign meteorological satellites. The AMSU will replace MSU and SSU at the NOAA-K,L,M satellites; 1.6-micrometer channel will be added to AVHRR, and channels of weather and infrared split windows will be added in the GMS-5. Late in the Ninth Five-Year Plan Period, after the EOS is launched, a large number of modern remote-sensing instruments will be carried to acquire possibly some new remote-sensing data from modern remote sensing satellites of the United States, Japan, and the European countries. Moreover, within the Ninth Five-Year Plan period, China will continuously launch FY-1 (lot number 02) polar-orbit meteorological satellite and FY-2 geostationary orbit satellite with more development of the second-generation polar-orbit and geostationary satellites FY-3 and FY-4. Around the year 2000, an operational monitoring system with the integration of polar and geostationary orbiting satellites will be formed. Coordinating with this situation, further development of ground systems of meteorological satellites will be carried out. For example, since five channels of the scanning radiometer of FY-1 (lot number 02) is modified into ten channels, and 300min of 4KM digitized cloud map data will be stored in the satellite, therefore both code rates of real time and delayed graphics are 1.33mbps. Thus, receiving systems should be modified, and computer systems expanded. Rapid progress in computer technology to enable data processing

formerly only attainable on mainframes is presently achievable at

workstations or high-grade microcomputers. Thus, distributed

configuration can be used for data processing of meteorological

satellites so that the systems have higher performance-to-price

ratios.

Recently, the nation-wide VSAT meteorological communication

system will be built at the China Meterological Administration,

thus providing advantageous conditions for the distribution of

meteorological satellite outputs. Moreover, after the launch of

the FY-2 satellite, quite large capacity of data can be included

in the expanded information. While receiving the FY-2 expanded

information by a medium-schedule utilization station, the

inserted information can be separated by using software. Thus,

it is projected in the Ninth Five-Year Plan period, high timing

effectiveness of meteorological satellite data distributing

system can be formed throughout the nation, to further expand

applications of meteorological data, and to further upgrade the

application level.

With respect to hardware layout, on receiving, processing,

and communication transmission of meteorological satellite data,

it is scheduled that the solution to a certain extent can be

achieved in the nineties. However, the most important in

developing meteorological satellite applications is data

processing and application theory, in addition to the study of

schemes and software development. In this respect, much work

remains to be done. For example, it is required to further

perform the applications of marking with visible light, infrared and microwave data, precise positioning, atmospheric modification, cloud inspection, graphic processing, evolution of atmosphere and surface property parameters, generation of the various databanks, and geographic information systems. It is scheduled, in the nineties, that major progress will be achieved in this respect so that the data receiving and processing systems of meteorological satellites will enter the stage of gradual upgrading for sufficient exploitation of effectiveness.

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